FOUR PROBLEMS WITH GLOBAL CARBON MARKETS: A CRITICAL REVIEW

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ABSTRACT

This article offers a critique of global carbon markets and trading, with a special focus on the Clean Development Mechanism of the Kyoto Protocol. It explores problems with the use of tradable permits to address climate change revolving around four areas: homogeneity, justice, gaming, and information. *Homogeneity* problems arise from the non-linear nature of climate change and sensitivity of emissions, which complicate attempts to calculate carbon offsets. *Justice* problems involve issues of dependency and the concentration of wealth among the rich, meaning carbon trading often counteracts attempts to reduce poverty. *Gaming* problems include pressures to promote high-volume, least-cost projects and the consequences of emissions leakage. *Information* problems encompass transaction costs related to carbon trading and market participation and the comparatively weak institutional capacity of project evaluators.

Keywords: European Union; United States; carbon credits; Clean Development Mechanism; Kyoto Protocol

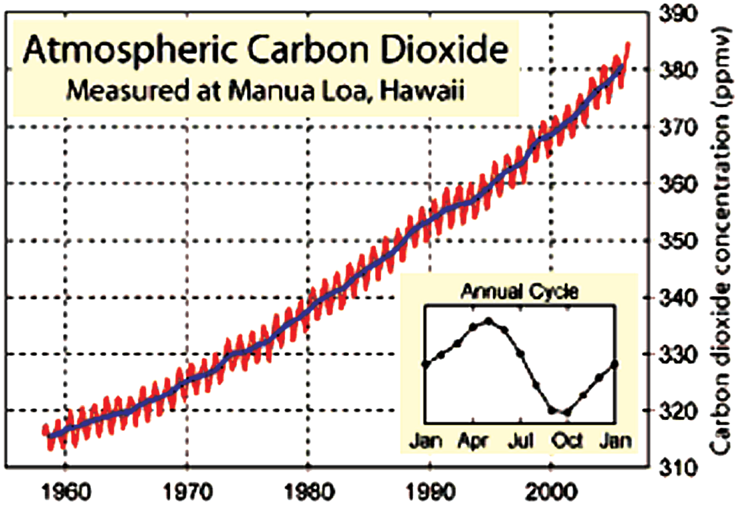
1. INTRODUCTION

One can hardly claim to have an acceptable solution to mitigating greenhouse gases without mentioning market-based mechanisms such as carbon caps, credits, quotas, and trades. Regional carbon credit trading mechanisms are in place in Europe and North America, millions of credits have been traded under the Kyoto Protocol or purchased on the voluntary market, conferences and reports about such tools multiply, academics pen countless articles, and international discussions never stray too far from the core theme of harnessing tradable credits to provide incentives to reduce greenhouse gas emissions. Even Halldor Thorgeirsson, director of the United Nations Framework Convention on Climate Change (and organizer of the Bali climate change talks in December 2007), has remarked that "effective carbon market mechanisms" would be the "key component" of any post-2012 climate change regime (Sovacool and Carroll 2008).

This article offers a critique of global carbon markets and trading. It asks: what problems exist with the use of tradable permits and market instruments to address climate change? Based on a critical review of the academic literature, it divides these problems into four categories: homogeneity, justice, gaming, and information. *Homogeneity* problems arise from the non-linear nature of climate change, which complicate attempts to calculate carbon offsets. *Justice* problems involve issues of dependency and the concentration of wealth among the rich, meaning carbon trading often counteracts attempts to reduce poverty. *Gaming* problems include pressures to promote high-volume, least-cost carbon credit projects and the consequences of emissions leakage. *Information* problems encompass transaction costs related to carbon trading and market participation and the comparatively weak institutional capacity of project evaluators.

In explicating these four problems with carbon credits, it is necessary to expound upon a few key terms. By having the word "critical" in its title the article is *not* meant to fully weigh the costs and benefits of carbon markets. Rather, it identifies only key problems; it is therefore unabashedly one-sided. The article is a "review" in the sense that it relies entirely on secondary sources of data (albeit those that the author considered the best ones). The review is "global" in the sense that it focuses primarily on the trading of carbon credits under the Kyoto Protocol, praised for rapidly becoming what Lohman (2009) has called the "world's biggest commodity market" for carbon credits with "volumes comparable to credit derivatives inside of a decade." Nonetheless, the article does offer a sprinkling of examples from other areas such as regional emissions trading in the United States and the European Union Emissions Trading Scheme (EU-ETS). The article focuses intently on the Kyoto Protocol (mostly through its CDM) because it involves more than three thousand projects with still more in the pipeline, two billion credits (each one a ton of carbon dioxide equivalent), $15 billion in annual revenue, and cumulative credit purchases of about $100 billion (Hepburn 2007; Fernandez 2008; Wara and Victor 2008). The CDM has also spawned efforts such as the Worldwide Fund for Nature's Gold Standard and the World Bank's Community Development Fund which aim to be more sustainable, inclusive, effective, and targeted at addressing poverty and development goals (Nussbaumer 2009).

Notwithstanding these caveats, the article does have a few strengths. The first is its breadth. The author reviewed more than 300 articles discussing the merits and drawbacks of the Kyoto Protocol and global carbon trading over the past decade and references a small sample here. Rather than limit the review primarily to politics and economics journals, the author also assessed the atmospheric science, ecology, energy policy, development studies, sociology, natural resource management, public policy, and legal literature. Second, the article approaches this critical review with an appreciation for the intersections between carbon credit trading and development goals with a special emphasis on equity and poverty. Some studies have argued that development experts often uncritically assume that there is an automatic synergy of climate and development policies, particularly in the case of climate change mitigation, and that carbon markets facilitate the distribution of modern energy services, technology transfer, and job creation (Michaelowa and Michaelowa 2007; Rose et al. 1998). This article critically tests those claims.



Source: IPCC 2007.

Figure 1: Atmospheric Carbon Dioxide, 2005

2. THE PROBLEM OF HOMOGENEITY

At the most fundamental level, carbon markets are problematic because they often presume that the relationship between emissions and climate change is a linear one, that a one-to-one tradeoff is present between emissions and offsets, and that a carbon credit is "homogenous" or "equally valuable" independent of when and where carbon dioxide was emitted. Each of these assumptions is wrong.

To begin, it is necessary to briefly trace the scientific background of climate change. As Figure one shows, the Earth's atmosphere is currently at a carbon dioxide concentration of about 390 parts per million (ppm), and many climatologists have argued that carbon dioxide concentrations will need to be stabilized at 450 ppm in order to limit temperature increases to two degrees Celsius (Dutt 2009; Dutt 2010). The atmospheric concentration of carbon dioxide is growing at 2.5 parts per million per year.

Many chemical compounds found in the Earth's atmosphere act as greenhouse gases. These gases allow sunlight to pass through the atmosphere, but when the sunlight is reflected back toward space as infrared radiation, greenhouse gases absorb it and trap heat near the earth's surface. The most abundant greenhouse gases are naturally occurring water vapor, carbon dioxide, methane, nitrous oxide, and ozone, although there are numerous highly potent anthropogenic types including chlorofluorocarbons, hydrochlorofluorocarbons, and bromofluorocarbons.

It is helpful to view the climate change issue through the lens of carbon stocks and flows. The Earth's natural carbon cycle involves depositing carbon dioxide in the atmosphere and carbon in the plants and trees on land, underground as fossil fuels, and in the oceans over thousands of years. Burning fossil fuels and releasing greenhouse gases disrupts the flow, dumping too much carbon to be naturally cycled. Since the onset of the Industrial Revolution about 300 billion metric tons (gigatons) of carbon have been released into the atmosphere, and about 49 gigatons are currently added to the atmosphere each year.

In thinking about carbon cycles and flows, it is appealing to presume that a linear relationship exists between a ton of carbon dioxide emitted and its affect on climate change, and also that the impacts of climate change will unfold in a predictable fashion. Sadly, however, these claims are both incorrect. Climatologists and atmospheric scientists have recently warned of the likelihood of tipping points, or climate-forcing beyond which changes are impossible to reverse (Weitzman 2007; Speth 2008; Meze-Hausken 2008). Most people are used to thinking of climate change as the turning of a dial, but a better metaphor is the flicking of a switch. The "threshold" at which emissions trigger changes in climate are poorly understood, abrupt, and often invisible. Potentially serious tipping points, situations that once started would be impossible to stop, include the sudden collapse of the Greenland and West Antarctica ice sheets, which melt in bursts, meaning even a few degrees of warming could provoke entire glacial collapses or release methane from thawing permafrost. The ability for land and forests to store carbon is not uniform or permanent, since soils and plants can dry out, burn, or degrade, reducing the ability for ecosystems to remove and cycle carbon dioxide from the air. The ocean's ability to act as a carbon sink gradually becomes reduced over time due to increases in water temperature, the presence of pollution, and increases in acidity. Practices such as deforestation and mining can release large quantities of methane from underground peat bogs and wetlands, meaning a single activity (such as clearing an acre of forest) could unpredictably emit thousands of equivalent tons of carbon dioxide into the atmosphere. The lesson appears to be that both emissions sources and consequences can be full of surprises, irreversible changes, and non-linear interactions. While we may be uncertain about what these limits are, nature is an accountant that makes no errors, and all it may take to induce rapid climate change are a few tons of carbon dioxide emitted at the wrong place at the wrong time.

There is also evidence that once emitted, concentrations of carbon dioxide are largely irreversible, at least on a human timescale. Solomon et al. (2009) found that once discharged the average ton of carbon dioxide remains in the atmosphere for about one thousand years. The upper range of estimates from Archer et al. (2009), Hansen et al. (2008), and Archer (2005) are even more worrying, suggesting that once emitted some carbon dioxide will remain in the atmosphere for 35,000 years. Thus, reversing the damage done from a single ton of carbon dioxide may only be possible on a geologic timescale of millennia (Hardin 1986). Put simply: not all tons of carbon dioxide are equal, their impact will differ by both place and time.

Despite our scientific understanding that the relationship between emissions and climate change is complex and non-linear, and that no one-to-one relationship exists between a ton emitted and its effect on climate change, carbon markets are designed around the notion of offsets. A country wishing to emit a ton of carbon dioxide under the Kyoto Protocol can still do so as long as it "offsets" that ton by purchasing a carbon credit or conducting an activity somewhere else to reduce greenhouse gas emissions. Put another way, for every single ton of greenhouse gas avoided or offset abroad, an investor is permitted to emit one more ton at home. Potential offsets under the Kyoto

Protocol and other carbon markets include forest sequestration, agricultural sequestration, methane capture and destruction from coal mines and landfills, repair of gas leaks associated with circuit breakers that use sulfur hexafluoride, fuel switching to natural gas, energy efficiency practices, and the promotion of wind and solar power plants. Thus, a factory in Denmark can still emit 100 tons of carbon dioxide as long as it offset its emissions by planting trees in Africa to sink the same 100 tons.

The problems that arise with offsets are manifold. Some types, such as planting plantations of eucalyptus to sink carbon, damage biodiversity and degrade land. The goal of such projects is to sink as much carbon as possible, not to promote a diverse and healthy ecosystem. Such offsetting usually involves replacing native forests and grasslands with fast growing trees that absorb more carbon but also divert water from local residents, require pesticides, and displace communities from land. The practice of offsetting does not encourage a reduction in total greenhouse gas emissions, only that countries offset their emissions elsewhere else, making them carbon neutral (Prouty 2009; Lohman 2009; Bernow et al. 2001). In this way, global carbon markets do little to truly address the potentially irreversible impacts from climate change.

A second concern arises because the practice of offsetting is based on the premise that a one-to-one relationship between pollution and abatement exists. The energy-intensive nature of some offsets, such as carbon capture and sequestration, invalidates the assumption behind an equal relationship between emissions and offsets: in many cases, two to three tons of carbon dioxide must be sequestered to offset every ton emitted (Sovacool and Carroll 2008). Moreover, efforts to offset carbon such as afforestation and injection of carbon dioxide into natural carbon sinks become less effective at fighting climate change the more they are utilized because of saturation. Many trading proposals currently discussed involve reforesting areas in developing countries or protecting existing forests and grasslands to absorb carbon emissions. However, the actual capacity of forests and grasslands to absorb carbon is unknown, and evidence suggests that forests and agricultural lands cannot store carbon indefinitely. McKinsey (2008) estimated that existing forests, even if undisturbed, will be able to absorb 100 million tons of carbon dioxide less by 2030 because of saturation. Furthermore, such projects also run the risk of contributing dangerously to climate change when floods, more severe weather, new strains of disease and altered land practices impair, destroy, or harvest forests. This transforms forests from sinks (vegetation that absorbs carbon dioxide) to sources (vegetation that releases carbon dioxide). Also at issue is the legitimacy of credits; the maximum time forestation projects guarantee credits is 100 years, a fraction of the thousands of years such forests would need to safely store carbon (Reijnders 2009).

Global carbon markets operate on the assumption that a carbon credit has the same value whether it is emitted during the day or night, or in Jakarta or Jerusalem. Yet the source of emissions differs greatly by space and time. For example, airplanes traveling during the day reflect radiant energy from the sun and produce a contrail absorbing more heat, meaning daytime flights have less effect on climate change than nighttime flights (Travis et al. 2002). Greenhouse gases such as nitrous oxide and ozone are also incredibly dependent on the times and location of their source. On calm, sunny days with temperature gradients that trap emissions, the production of ozone from automobiles, factories, and power plants will be high; days with rainfall and wind will experience much less ozone production (Solomon and Gorman 1998; Farrell et al. 1999; Farrell 1991–1992).

In addition, new research in atmospheric science has refuted the common belief that globally emitted carbon dioxide does not affect a particular location more or less than any other, and that because carbon dioxide becomes uniformly mixed into the atmosphere, emissions from within one location do not affect climate any more or less than from those outside the region. Jacobson (2009) has found that locally emitted carbon dioxide can form "domes" that trap emissions near their sources, interacting with local ozone and concentrations of particulate matter or sulfur dioxide. Globally emitted carbon dioxide, furthermore, does not increase surface temperature uniformly. The interactions between carbon dioxide, water vapor, and other atmospheric elements will be particular to each region. The implication is that the same ton of carbon dioxide will result in very different local effects.

3. THE PROBLEM OF JUSTICE

Global climate markets raise critical questions about justice since they tend to benefit the countries that are most industrialized (or industrializing), not those most in need; do not transfer intellectual property and technology to developing countries; and give the "best" locations and projects to transnational corporations and firms.

First, since the CDM is itself a competitive mechanism, projects have favored nations that have already begun industrialization. The great majority of these projects have occurred in strong economies such as Brazil, China, and India, where institutions and markets are in place to reassure investors (Nussbaumer 2009). The poorest countries that lack such capacity (and are perhaps most in need of projects) have been avoided. Thus, CDM trading has locked in and may exacerbate inequalities between countries (Lohman 2006).

Second, the intellectual property rights for many high tech low-carbon approaches and technologies lie with Western technology firms, and investors have quickly exploited the "best" locations and most profitable projects. This means that when developing nations become obligated or committed to cut their own emissions, they will be left with only the least cost-effective regions. In situations where countries in the developing world have not been able to guarantee protection of intellectual property, technology transfers simply have not occurred. For instance, wariness about weak patent protection has deterred the distribution of innovative technologies from the United States to Asia, as firms believe they would be at a competitive disadvantage to share technology. In addition, host companies in developing countries have shown a reluctance to acquire technology that they believe competitors in other nearby countries could freely copy in their own markets. Such concerns have been found to complicate (and at times prevent) plans to disseminate efficient industrial boilers, fluidized bed combustion, coal gasification systems, various end-of-pipe pollution abatement technologies such as carbon capture and storage, hydrogen fuel cells, wind turbines, solar panels, and batteries for electric vehicles (Sovacool 2008a). Developing countries are thus dependent on developed countries for access to technology, an ironic situation since the superior ability for developed countries to develop this technology (and adjust to climate change) is largely based on their "ongoing abuse of the atmosphere and the continued prosperity their polluting technologies provide" (Prouty 2009, p. 517).

Even when developing countries are able to license and use low-carbon technology, or host CDM projects, foreign firms often take the cheapest and best abatement options for themselves, creating what some have called the "low-hanging fruit," "cream skimming," or "cherry picking" problem. Indeed, one survey of global CDM projects found that they ended up deterring most host countries for implementing their own cost-effective projects due to lack of suitable sites (Narain and Veld 2008).

Ultimately, the confluence of these trends—a preference for industrializing economies; possible dependence on Western firms for technology; and lack of optimal sites—has meant that carbon markets rarely, if ever, reduce poverty and meet millennium development goals. Sutter and Parrano (2007) evaluated 16 registered CDM projects in Brazil, Honduras, India, South Korea, Bhutan, Bolivia, China, Chile, and South Africa (involving a variety of projects including landfill gas recovery, construction of hydroelectric facilities and wind farms, electricity generation from crop residues, natural gas fuel switching, weatherization and housing upgrades) and looked at their propensity to generate jobs, reduce poverty, improve local air quality, and reduce emissions. They concluded that virtually none of the projects scored high on meeting development goals and reducing emissions simultaneously, finding that 95 percent had "little value for development."

Similarly, Sirohi (2007) analyzed whether CDM projects in India actually contributed to poverty alleviation in rural areas and found that landless laborers did not benefit and that, instead, many CDM projects increased prices in some agricultural commodities. Moreover, employment benefits for poor and unskilled laborers were extremely limited, projects were generally concentrated in areas with far-above average incomes, and benefits tended to accrue to a limited number of elites. Michaelowa and Michaelowa (2007) surveyed climate change projects being undertaken in the developing world and concluded that they resulted in only "limited" benefits at meeting millennium development goals. They noted that projects addressing poverty were very rare and that even small renewable energy projects in rural areas usually benefitted rich farmers and the urban population at the expense of the poor. Olsen (2007) carried out a meta-analysis of 19 studies on the CDM and actually discovered a tradeoff between the CDM target of supplying cheap emissions credits and the promotion of sustainable development, with the former taking priority over the latter. Olsen concluded that the CDM did not drive sustainable development goals, did not promote renewable energy projects, privileged projects that brought in investment (rather than those that promoted development), and did not benefit poor households. In some cases, CDM projects actually *worsened* development goals by interfering with land use practices, increasing the price of fuelwood, or forcibly relocating communities.

4. THE PROBLEM OF GAMING

Three types of gaming issues arise in carbon credit trading: some projects can create revenues that fund fossil fuel production, greenhouse gases of particularly high value can be emitted just to generate credits, and "leakage" of emissions between regions can become quite severe.

Although the CDM and other carbon markets are intended to give value to cleaner sources of energy production and use, some regulators have designed (and approved) projects that support fossil fuels. For example, one offshore oil platform in Vietnam and two coal mines in China were approved for 17 million carbon credits for capturing and using methane as part of their operations. While such projects are technically within the CDM boundary, they unavoidably produce revenues that will be funneled back into coal and gas production, operating as indirect subsidies for those fossil fuel chains and companies (Pearson 2007). Similarly, credits have been awarded for low sulfur coal and coal washing because such options are a low-cost investment for CDM credits; firms can earn credits for as little as \$3 per ton for these “cleaner” types of fossil fuel processes whereas building wind and solar projects cost between \$12 and \$15 per credit (Prouty 2009).

Furthermore, there is mounting evidence that some types of carbon credits have become so easy to produce (and valuable) that firms will emit greenhouse gases only to then stop emitting them to produce credits. About half of all accredited CDM projects have involved not carbon dioxide, but the greenhouse gas triflouromethane, or HFC-23. Industries produce HFC-23 as a byproduct in the manufacturing of refrigerant for air conditioners and feedstocks for high performance plastics and the manufacturing of Teflon (Sovacool and Brown 2009). Unfortunately, the CDM has made HFC-23 abatement too profitable, and the sale of carbon credits generated from HFC-23 offsetting has become far more valuable than its production for other purposes. Manufacturers of HFC-23, responding to the market demand for credits, started producing it just to offset it. Researchers at Stanford University have calculated that, as a result, payments to refrigerant manufacturers and carbon market investors by governments and compliance buyers for HFC-23 credits has exceeded \$4.7 billion when the costs of merely abating HFC-23 would have been about \$100 million—a major manipulation of the market (Wara, 2007; Pearson 2007; Wara & Victor, 2008).

Strategic gaming is not limited to HFC-23. Nitrous oxide is 298 times more dangerous than carbon dioxide, and as such a firm can generate hundreds of carbon credits just by eliminating one ton of nitrous oxide. In South Korea, for example, Rhodia invested \$15 million in equipment that destroys nitrous oxide to produce \$1 billion in carbon credits for sale to industries around the globe. Trades of these credits do nothing to reduce greenhouse gases and are also often sold to fossil fuel companies, encouraging those places to continue to invest in carbon-intensive energy supplies. Rhodia already makes 35 times more money destroying nitrous oxide than it does from selling products at their South Korean plant (Lohman 2009).

A final gaming concern involves leakage, or a shift of emissions to areas with the poorest governance structures and most lax regulations. Two kinds of leakage can occur: between locations (i.e., a European chemical firm locates to a developing country to escape regulation, or American investors choose to plant a forest where the most amenable regulations exist), and market leakage (when restrictions on emissions result in changes in price that then have deleterious effects on climate and energy policies) (Ostrom 2009). Numerous examples of locational and market leakage exist.

Electric utilities operating in the Pacific Northwest of the United States must currently supply electricity to states with and without mandatory emissions regulations. They have thus strategically built polluting power plants only in states without emissions regulations. PacifiCorp has repeatedly attempted to build coal-fired power plants in Wyoming and Utah, states without mandatory greenhouse gas reduction targets, but not in Oregon (which has mandated a stabilization of greenhouse gas emissions by 2010) and Washington (which has mandated 1990 levels by 2020). The state-by-state patchwork of climate change policies in the U.S. has allowed firms to manipulate the existing market to their advantage (Sovacool 2008b).

On the other side of the United States, a collection of Northeastern states have formed the Regional Greenhouse Gas Initiative, or RGGI. RGGI is a carbon cap-and-trade program where fossil fuel plants are allotted a certain number of allowances that permit emission of greenhouse gases. The program, however, has created perverse incentives for generators to lower emissions by purchasing energy from fossil fuel plants in neighboring states that do not have carbon restrictions. Estimates for RGGI have shown leakage rates as high as sixty to ninety percent due to the importation of electricity alone, as power plants in adjacent states have increased their output to sell into the higher-priced electricity markets in RGGI states (Wiener 2007).

The danger of this leakage is threefold. Most obviously, it undermines the environmental effectiveness of any restrictions on greenhouse gas emissions, and if leakage exceeds 100 percent (something possible given the experiences with RGGI), net emissions of greenhouse gases could hypothetically increase. Even if physical leakage does not occur, the fear of leakage and its adverse effects on economic competitiveness may create political obstacles to meaningful climate change action. Finally, leakage has a tendency to lock in asymmetries between carbon-intensive and climate-friendly regions and commit nonparticipants to a path of future emissions. As leakage proceeds over time, it shifts greenhouse gas emissions from regulated regions to unregulated ones. It thereby renders the unregulated region's economy more emissions-intensive than it otherwise would have been, making it more difficult to persuade communities that initially decided to avoid participation ever to commit to greenhouse gas reductions (Wiener 2007; Bernow et al. 2001).

Though global carbon markets assume that a carbon credit has the same value regardless of the type of project, in reality many types of credits tradeoff with each other or at least fail to seriously mitigate emissions (Michaelowa 2001; Sovacool and Brown 2009; Ostrom 2009). Investing in natural gas supply to offset coal, for example, also reduces the effectiveness for energy efficiency and erodes incentives to invest in wind energy because it commits money to long-lived, capital intensive fossil-fuel infrastructure. Promoting mass transit and buses as alternatives to driving private automobiles can mitigate incentives for cycling and walking. Creating incentives for rural populations to move into urban areas can minimize the energy needed for private automobiles and provide opportunities for district heating and the recycling of thermal energy, but can also contribute to urban heat islands and increase the risk of flooding and urban sprawl, which tend to lower the resilience and adaptive capacity of communities. In these instances, pursuing one type of credit (or activity generating credits) can reduce the need to invest in or can actually conflict with other sources of credits.

5. THE PROBLEM OF INFORMATION

Knowledge and information problems with carbon markets, separate from the issues described above (which to a degree all involve knowledge in some way), include transaction costs as well as the institutional capacity of approvers and auditors of credits and projects.

The entire process of designing a project, having it reviewed and audited, and then evaluating credits takes years and involves a substantial number of transaction costs. Traders and brokers often get a commission of 3 to 8 percent of the value of the credit (with an industry average of 5 percent). This amount may not sound like much, but it means that every $1 billion in trading will involve annual transaction costs on the order of $50 million. CDM projects carry additional risk, making them more expensive, since credits are not approved until after project is completed, making the market price for credits unpredictable and more volatile (Lof 2009).

Further complicating matters, many of the efforts to revise the CDM to make it more accountable and oriented towards meeting development goals have only *increased* transaction costs. The World Bank's Community Development Carbon Fund (CDCF), for example, focuses on promoting small-scale CDM projects in low income countries. Yet because the CDCF involves extra layers of approval (including stipulations that no more than 10 percent of the Fund's assets contribute to projects in the same country and that 25 percent must go towards the least developed countries), projects take much longer to approve (Nussbaumer 2009). One survey found that more than 60 percent of respondents identified transaction costs such as time for approval and registration with the CDM Executive Committee as major barriers towards investing global carbon markets (Boyle et al. 2009).

A second type of knowledge problem relates to project approval and the institutional capacity of approvers. The CDM Executive Board, for instance, relies on third party verifiers to check claims made by project proponents. One shortfall is that these verifiers are often paid by project developers, meaning they have an incentive to approve all projects they investigate. The Executive Board is also notoriously understaffed and therefore overwhelmed with issuance requests. As of late 2008, more than 950 individual carbon offset projects achieved registration in CDM (the final stage) but a further 2,000 projects were at various stages seeking registration and a staggering 5,000 to 10,000 requests will need approved by 2012 (Wara and Victor 2008).

The CDM faces difficulties in another sense as well: the United Nations certifies credits through global consultants. Consequently, outside contractors often approve CDM projects that they should not and sometimes fail to certify those that they should. One study, after evaluating 93 randomly chosen CDM projects, found that in a majority of cases the consultants hired to validate CERs did not possesses the requisite knowledge needed to approve projects, were overworked, did not follow instructions, and spent only a few hours evaluating each case (Schneider, 2007). This seems especially true with China, where an independent study has warned that 71 percent of approved CDM hydroelectric projects should not have been certified (Haya, 2007), and India, where CDM certification has been outsourced to foreign companies that have approved 52 illegitimate projects (Michaelowa & Purohit, 2006). Another study of the global performance of the CDM estimated that about 40 percent of projects accounting for 20 percent of expected CERs in the global market were questionable (Boyle et al. 2009).

6. CONCLUSIONS

This article has critically assessed the performance of global carbon markets, especially the Clean Development Mechanism of the Kyoto Protocol, and has found such schemes to be prone to problems of homogeneity, justice, gaming, and knowledge. The relationship between emissions, offsets, and climate change is complex and non-linear and will differ greatly over space and time, yet carbon markets treat credits as homogenous and uniformly traded commodities. Climate trading has so far made some developing countries more dependent on western technology and exacerbated gaps between rich and poor, in some cases escalating agricultural and fuel prices in impoverished areas and interfering with indigenous land practices. Many firms have quickly learned to game the climate trading system and started emitting greenhouse gases just so they can make money offsetting them. Carbon markets have substantial transaction costs that transfer wealth to brokers and agents, and evaluators of often lack the capacity to distinguish legitimate from illegitimate projects.

The confluence of these factors may explain why global (and regional) carbon markets have so far failed to make a meaningful difference in mitigating greenhouse gas emissions. The overall reduction commitment by Annex 1 countries under the Kyoto Protocol was to achieve reductions 5.2 percent below 1990 levels by 2012, yet emissions among these countries have actually increased 8.4 percent *above* 1990 levels and global temperatures are projected to increase 1.8 to 4.0 degrees Centigrade by the end of the century (Huq and Alam 2008). At the root of these issues is a common theme: carbon markets are imperfect devices that often transfer and consolidate power and wealth. Perhaps one of the reasons carbon markets remain "key components" of any attempt to reduce greenhouse gas emissions is not because they are the most efficient or effective, but because the problems of homogeneity, justice, gaming, and knowledge enable firms and traders to benefit from climate change at precisely the moment when it has finally attracted the attention of policymakers and global leaders.

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